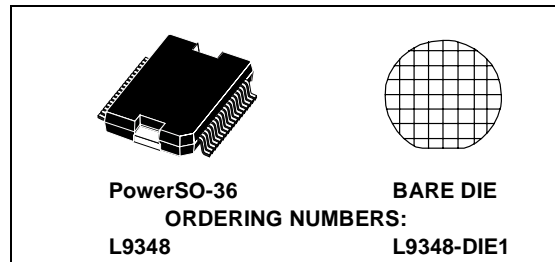# L9348

QUAD LOW SIDE DRIVER

- SUPPLY VOLTAGE RANGE: 4.8 TO 18V
- OUTPUT VOLTAGE UP TO 40V
- OUTPUT VOLTAGE CLAMP DURING RECIRCULATION OF INDUCTIVE LOADS
- OUTPUT CURRENT CAPABILITY 2 X 5A AND 2 X 3A
- LOW POWER DISSIPATION DURING RECIRCULATION OF INDUCTIVE LOADS BY INTEGRATED FREE WHEELING DIODES (3A-DRIVERS ONLY)
- LOW ON-RESISTANCE 2 X 0.2Ω , 2 X 0.35Ω (TYP.)
- OUTPUT SHORT CIRCUIT CURRENT PROTECTION
- REAL TIME DIAGNOSTIC FUNCTIONS
- OVERTEMPERATURE SHUTDOWN
- SIGNAL- AND POWER-GROUND-LOSS SHUTDOWN

PowerSO-36 **BARE DIE**
ORDERING NUMBERS:
L9348 **L9348-DIE1**

- 3.3V CMOS COMPATIBLE INPUTS AND STATUS

DESCRIPTION

The L9348 is a monolithic integrated quad low side driver realized in advanced Multipower-BCD technology. It is intended to drive inductive loads (relays, electromagnetic valves) in automotive and industrial applications.
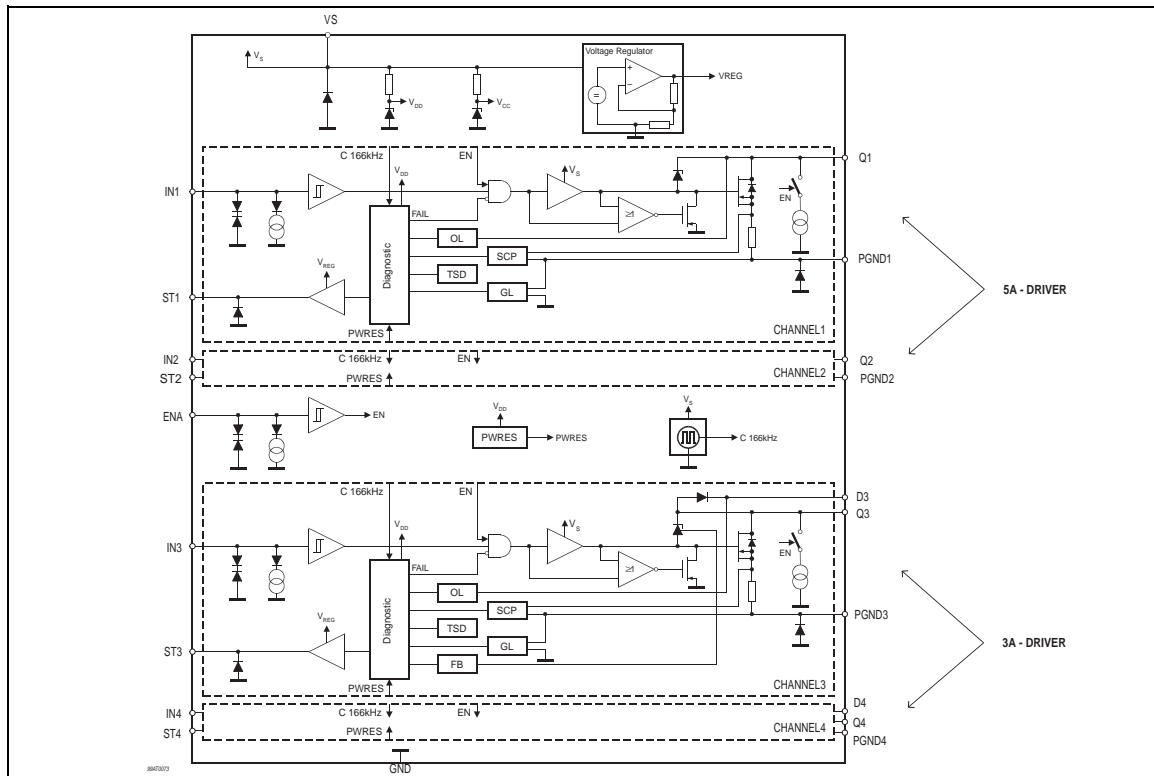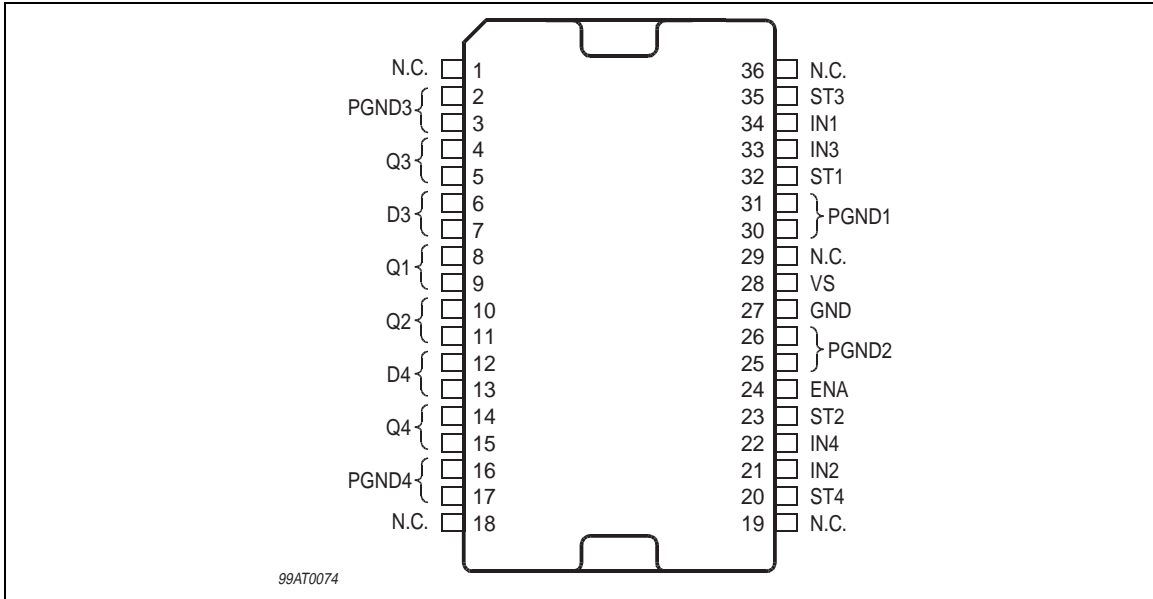
Figure 1. Block Diagram

Figure 2. Pin Connection

99AT0074

Table 1. Pin Description

N°	Pin	Function
1, 18, 19, 36	N.C.	(GND)
2, 3	PGND3	Power Ground Channel 3
4, 5	Q3	Power Output Channel 3 (3A switch)
6, 7	D3	Recirculation Diode Channel 3
8, 9	Q1	Power Output Channel 1 (5A switch)
10, 11	Q2	Power Output Channel 2 (5A switch)
12, 13	D4	Recirculation Diode Channel 4
14, 15	Q4	Power Output Channel 4 (3A switch)
16, 17	PGND4	Power Ground Channel 4
20	ST4	Status Output Channel 4
21	IN2	Control Input Channel 2
22	IN4	Control Input Channel 4
23	ST2	Status Output Channel 2
24	ENA	Enable
25, 26	PGND2	Power Ground Channel 2
27	GND	Signal Ground
28	VS	Supply Voltage
29	N.C.	Not Connected
30, 31	PGND1	Power Output Channel 3
32	ST1	Status Output Channel 1
33	IN3	Control Input Channel 3
34	IN1	Control Input Channel 1

Table 2. Thermal Data

Symbol	Parameter	Test Conditions	Values			Unit
			Min.	Typ.	Max.	
T_j	Junction temperature		-40		150	°C
T_{jc}	Junction temperature during clamping (life time)	$\Sigma t = 30min$ $\Sigma t = 15min$			175 190	°C °C
T_{stg}	Storage temperature		-55		150	°C
$R_{th\ j\text{-case}}$	Thermal resistance junction to case				2	°C/W

Table 3. Absolute Maximum Ratings
The absolute maximum ratings are the limiting values for this device. Damage may occur if this device is subjected to conditions which are beyond these values.

Symbol	Parameter	Test Conditions	Value	Unit
Voltages				
V_S	Supply voltage range		-0.3 to 40	V
V_Q, V_D	max. static Output voltage		40	V
V_{IN}, V_{EN}	Input voltage range (IN1 to IN4, EN)	$|I_I| < 10mA$	-1.5 to 6	V
V_{ST}	Status output voltage range	$|I_I| < 1mA$	-0.3 to 6	V
V_{DRmax}	max. Reverse breakdown voltage free wheeling diodes D3, D4	$I_R = 100\ \mu A$	55	V
Currents				
$I_{Q\ 1/2}$	Output current at reversal supply for Q1, Q2		-4	A
$I_{Q\ 3/4}$	Output current at reversal supply for Q3, Q4		-2	A
I_{ST}	Status output current range		-1 to 1	mA
$E_{Q1/2}$	max. Discharging energy for inductive loads per channel Q1, Q2	$T_j = 25°C$	50	mJ
		$T_j = 150°C$	30	mJ
I_{FDmax}	max. load current free wheeling diodes	$t < 5ms$	3	A
ESD Protection				
Supply and Signal pins		versus GND	±2	kV
Output pins (Q_X, D_X)		versus common ground (=short of SGND with all PGND)	±4	kV

Note: Human Body Model according to MIL883C. The device withstands ST1 class level.

Table 4. Operating Range.

Symbol	Parameter	Test Conditions	Values			Unit
			Min.	Typ.	Max.	
V_S	Supply voltage		4.8		18	V
T_j	Junction temperature		-40		150	°C

Table 5. Electrical Characteristcs

The electrical characteristics are valid within the operating range **(Table 4)**, unless otherwise specified

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Power Supply						
I_S	Supply current	$V_{IN1...IN4, ENA} = H$			8	mA
I_Q	Quiescent current (outputs OFF)	$V_{ENA} = L$			6	mA
$I_{D3/4}$	Quiescent current at pins D3/4	$V_{D3/4} \leq 18V$; $V_{IN3/4} = L$	10		400	μA
Diagnostic Functions						
$V_{QU1\ to\ 4}$	Output open load voltage threshold	$V_S \geq 6.5V$ $V_{EN} = X$; $V_{IN} = L$	0.3	0.33	0.36	x V_S
$I_{QU1\ to\ 4}$	Output open load current threshold	$V_S \geq 6.5V$ $V_{EN} = H$; $V_{IN} = H$	50		140	mA
$I_{QO1/2}$	Overload current threshold Q 1, 2	$V_S \geq 6.5V$	5	7.5	9	A
$I_{QO3/4}$	Overload current threshold Q 3, 4	$V_S \geq 6.5V$	3	5	8	A
T_{th}	Overtemperature shutdown threshold	2)	175		210	°C
T_{hy}	Overtemperature hysteresis			10		°C
V_{thPGL}	Power-GND-loss threshold		1.5	2.5	3.5	V
V_{thSGL}	Signal-GND-loss threshold		150	330	510	mV
Power Outputs (Q1 to Q4)						
$R_{DSON1/2}$	Static drain-source ON-resistance Q1, Q2	$I_Q = 1A$; $V_S \geq 9.5V$ $T_j = 25°C$		0.2		Ω
		$T_j = 125°C$ 3)			0.5	Ω
		$T_j = 150°C$ 4)			0.5	Ω
$R_{DSON3,4}$	Static drain-source ON-resistance Q3, Q4	$I_Q = 1A$; $V_S \geq 9.5V$ $T_j = 25°C$		0.35		Ω
		$T_j = 125°C$ 3)			0.75	Ω
		$T_j = 150°C$ 4)			0.75	Ω
V_Z	Z-diode clamping voltage = threshold of flyback detection Q3/4	$I_Q \geq 100mA$, pos. supply $V_{D3/4}$	45		60	V
V_C	Clamping voltage	$I_Q \geq 100mA$, neg. supply $V_{D3/4}$	4		10	V
I_{PD}	Output pull down current	$V_{ENA} = H$, $V_{IN} = L$	10	20	50	μA

Table 5. Electrical Characteristcs

The electrical characteristics are valid within the operating range **(Table 4)**, unless otherwise specified

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_{Qlk}	Output leakage current	V_{ENA} = L, T_j = 25°C			1	μA
		T_j = 125°C			5	μA
$V_{FD3/4}$	Forward voltage of free wheeling diodes D3, D4	$I_{D3/4}$ = -1.5A	0.5		1.75	V
R_{PD0}	Gate pull down resistor for nonsupplied V_S	V_S = 0V, $V_{D3/4} \geq 6.5V$	0.3		3	kΩ
Timings						
t_{ON}	Output ON delay time	I_Q = 1A [1]	0	5	20	μs
t_f	Output ON fall time	I_Q = 1A [1]	0.5	1.5	8	μs
t_{OFF}	Output OFF delay time	I_Q = 1A [1]	0	10	30	μs
t_r	Output OFF rise time	I_Q = 1A [1]	0.5	1.5	5	μs
t_{DSO}	Overload switch-OFF delay time		6	30	65	μs
t_D	Output OFF status delay time		0.75	1.5	2.25	ms
t_{filter}	error detection filter time	[2]	5.8		35	μs
t_{OLOFF}	OLOFF error detection filter time		20		70	μs
Digital Inputs (IN1 to IN4, ENA)						
V_{IL}	Input low voltage		-1.5		1	V
V_{IH}	Input high voltage		2		6	V
V_{IHy}	Input voltage hysteresis	[2]	50	100		mV
I_{IN}	Input pull down current	V_{IN} = 5V, $V_S \geq 6.5V$	8	20	40	μA
Digital Outputs (ST1 to ST4)						
V_{STL}	Status output voltage in low state [5]	$I_{ST} \leq 40μA$	0		0.4	V
V_{STH}	Status output voltage in high state [5]	$I_{ST} \geq -40μA$	2.5		3.45	V
		$I_{ST} \geq -120μA$	2		3.45	V
R_{DIAGL}	R_{OUT} + R_{DSON} in low state		0.3	0.64	1.5	kΩ
R_{DIAGH}	R_{OUT} + R_{DSON} in high state		1.5	3.2	7	kΩ

(1). See **chapter 2.0 Timing Diagrams**; resistive load condition; $V_S \geq 9V$

(2). This parameter will not be tested but assured by design

(3). Wafer-measurement

(4). Measured on P-SO36 devices

(5). Short circuit between two digital outputs (one in high the other in low state) will lead to the defined result "LOW"

1.0 FUNCTIONAL DESCRIPTION

1.1 Overview

The four low-side switches are designed to drive inductive loads (relays, electromagnetic valves). For the 3A switches (Q3/4) integrated free-wheeling diodes (D3/4) are available and can be used as recirculation path for inductive loads. If either integrated nor external free-wheeling diodes are used the output voltage is clamped internally during discharge of inductive loads. The switches are controlled by CMOS compatible inputs (IN1-4) if the enable input is set to "high". The status of each switch is monitored by the related status output (ST1-4).

1.2 Input Circuits

The control and enable inputs are active high, featuring switching thresholds with hysteresis and pull-down current sources. Not connected inputs are interpreted as "LOW". If the enable input is set to "LOW" the outputs are switched off independent of the control input state (IN1-4).

1.3 Switching Stages

The four power outputs consist of DMOS-power transistors. The output stages are protected against short circuit to supply. Integrated output voltage clamp limits the output voltage in case of inductive load current flyback. Internal pull down current sources are provided at the outputs to assure a defined conditon in OFF mode. They will be disconnected in the disable mode (ENA=L). If the supply of the device gets lost but the loads and D3/4 are still supplied, an internal pull down resistor discharges the gate of the DMOS-power transistor to avoid switch on due to capacitive coupling.

1.4 Status Outputs

The CMOS compatible status outputs indicate the state of the drivers (LOW-level indicates driver in OFF state, HIGH-level indicates driver in ON state). If an error occurs the status output voltage changes like described in **chapter 1.6 Error Detection**.

1.5 Protective Circuits

The outputs are protected against current overload, overtemperature, and Power-GND-loss.

1.6 Error Detection

Two main error types are distinguished in the diagnostic logic. If current overload, overtemperature, signal-GND-loss or a power-GND-loss occurs, the status output signal is inverted, an internal register is set and the driver is shutdown. The reset is done by switching off the corresponding control input or the enable input for at least the time t_D (defined to 1.5ms typ.). See also **Figure 6** in **chapter 2.0 Timing Diagrams**.

All other errors (openload, active output voltage clamp) only cause an inverted status output signal but no shutdown of the driver. An internal register is set too, but the reset is triggered automatically after the time t_D, if the error condition is no longer valid (see **Figure 7** and **Figure 8**).

Excepting the detection of the active output voltage clamp all errors are digitally filtered before they are interpreted by the diagnostic logic.

The table 6 below shows the different failure conditions monitored in ON and OFF state:

Table 6.

	ON State ENA = HIGH, IN = HIGH	OFF State ENA = HIGH, IN = LOW	typ. Filter time	Reset done by
Overloading of output (also shorted load to supply)	X		18µs	ENA or INx = "LOW" for t ≥ 1.5ms (typ.)
Open load (under voltage detection)		X	44µs	internal timer (1.5ms typ.)

Table 6.

	ON State ENA = HIGH, IN = HIGH	OFF State ENA = HIGH, IN = LOW	typ. Filter time	Reset done by
Open load (under current detection)	X		18µs	internal timer (1.5ms typ.)
Overtemperature	X		18µs	ENA or INx = "LOW" for t ≥ 1.5ms (typ.)
Power-GND-loss	X	X	18µs	ENA or INx = "LOW" for t ≥ 1.5ms (typ.)
Signal-GND-loss	X	X	18µs	ENA or INx = "LOW" for t ≥ 1.5ms (typ.)
Output voltage clamp active (Q3/4 only)		X	-	internal timer (1.5ms typ.)

1.7 Diagnostic Output at Pulse Width Operation (PWM)

If an input is operated with a pulsed signal (f ≥ $1/t_D$ = 667 Hz typ.), the status does not follow each single pulse. An internal delay t_D of typ. 1.5ms leads to a continuous status output signal (see **Figure 4** in **chapter 2.0 Timing Diagrams**).

1.8 Diagnostic Table

In general the diagnostic follows the input signal in normal operating conditions. If any error is detected the diagnostic is inverted.

Table 7.

Operating Condition	Enable Input ENA	Control Input IN	Power Output Q	Status Output ST
Normal function	L L H H	L H/PWM L H/PWM	OFF OFF OFF ON	L L L H
Open load or short to ground	L L H H	L H/PWM L H/PWM	OFF OFF OFF ON	X X H L
Overload or short to supply Latched overload Reset latch	H H H –> L H	H/PWM H/PWM X H/PWM –> L	OFF OFF OFF OFF	L L L L
Overtemperature Latched overtemperature Reset latch	H H H –> L H	H/PWM H/PWM X H/PWM –> L	OFF OFF OFF OFF	L L L L

2.0 TIMING DIAGRAMS

Figure 3. Output slope with Resistive Load

note: parameters are not shown proportionally

99AT0061
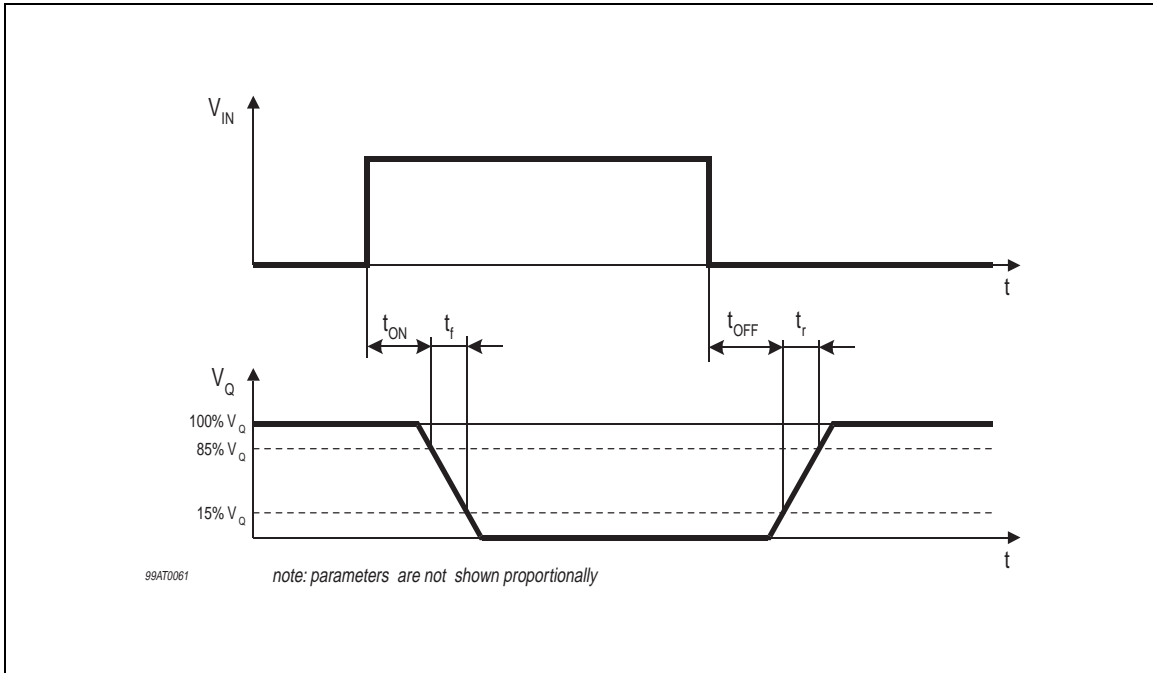
Figure 4. Diagnostic Output at PWM operation

delayed status signal

note: parameters are not shown proportionally

99AT0063
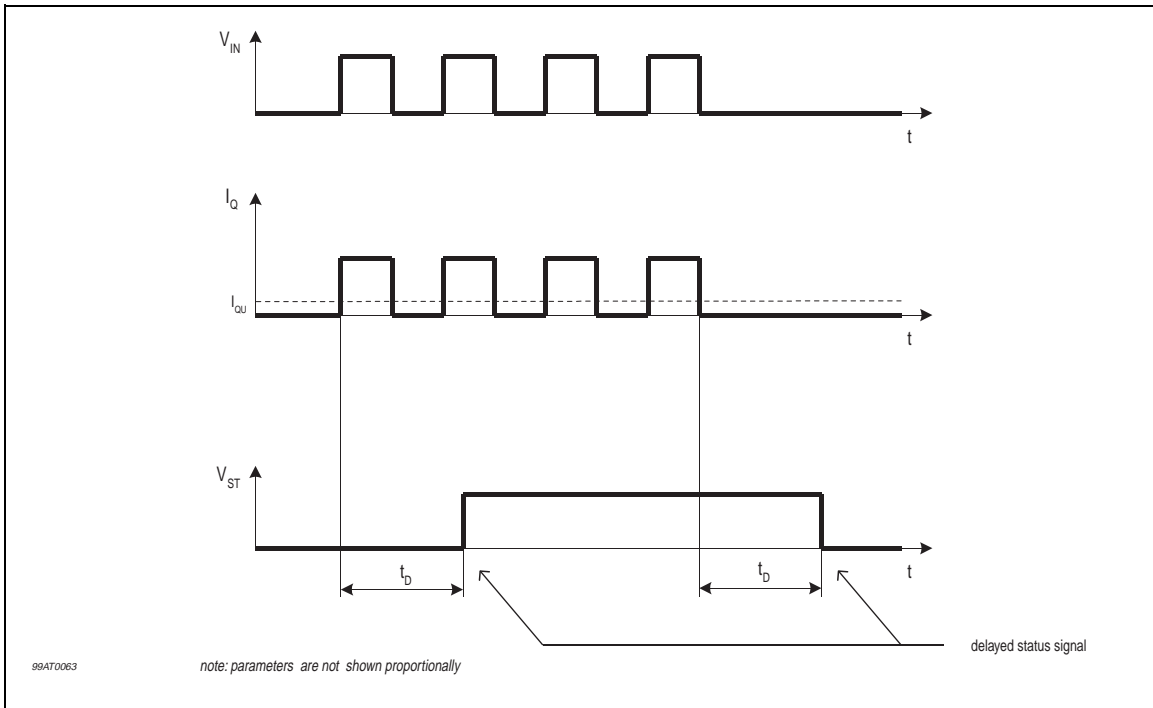
Figure 5. Overload Detection

V_{IN}

t

overload detected

I_Q

I_{QO}

driver shut down

I_{QU}

t

t_{DSO}

t_{filter}

V_{ST}

error condition signalized

t

99AT0062   note: parameters are not shown proportionally
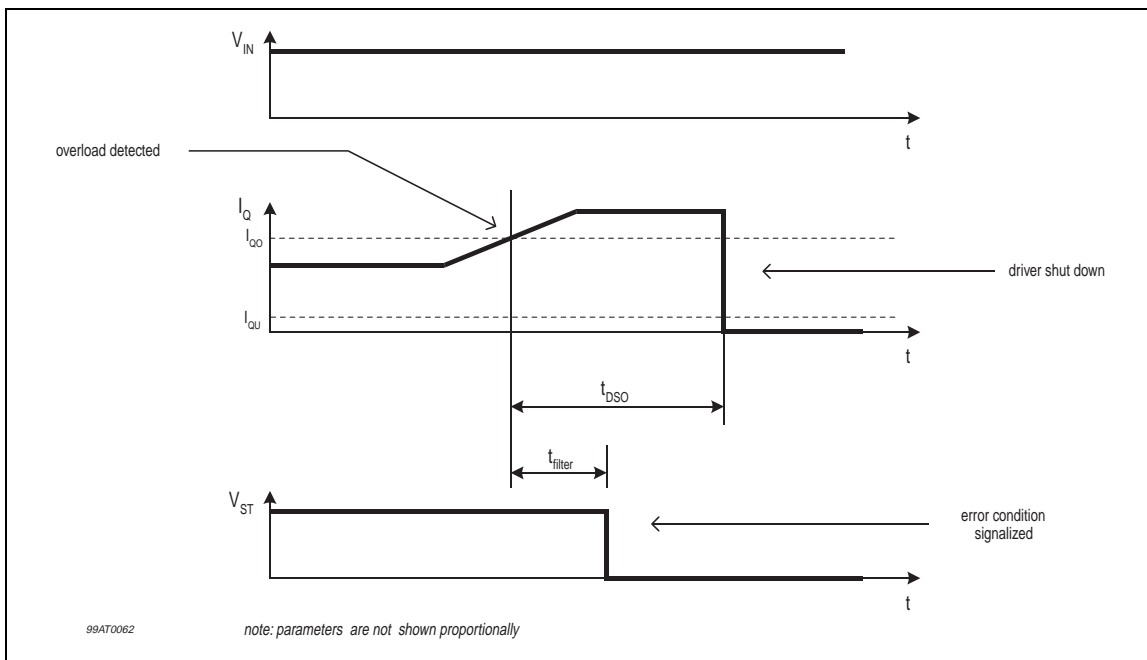
Figure 6. Driver Shut Down in Case of Overload

V_{IN}

t

driver is shuted down and locked

t_D

driver is now free again

I_Q

I_{QO}

t

V_{ST}

error is signalized

t_D

t

99AT0004   note: parameters are not shown proportionally
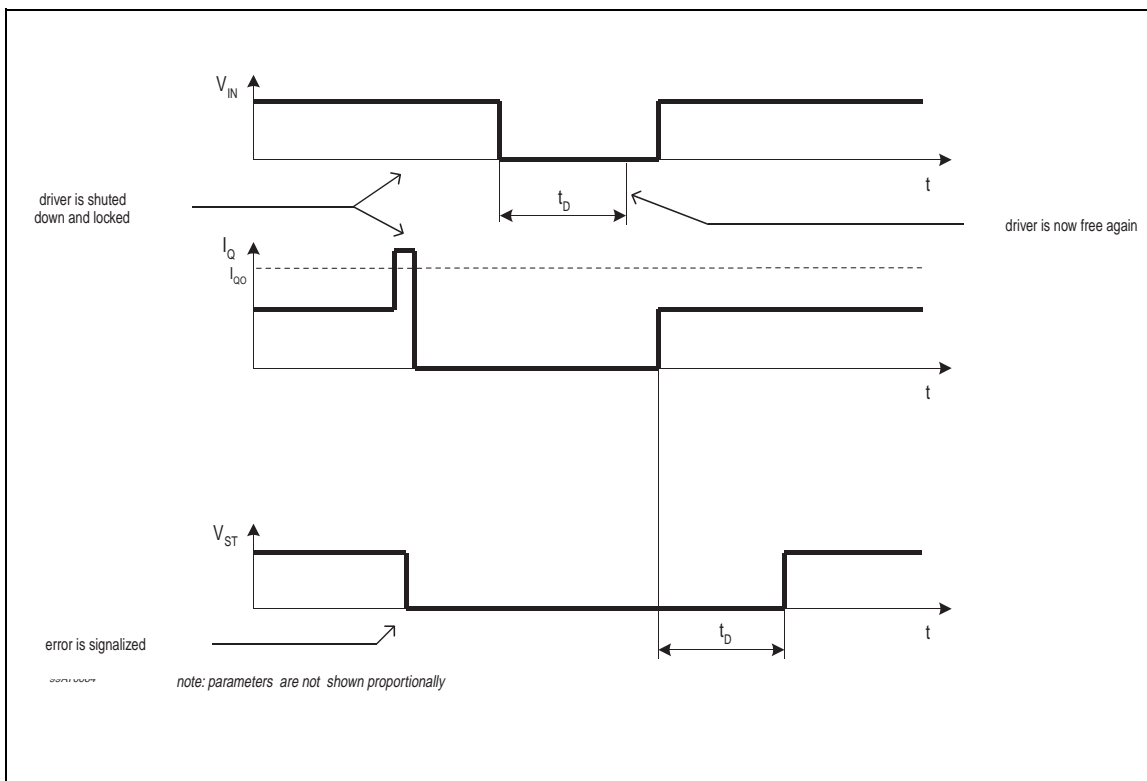
Figure 7. Under Current Condition

V_{IN}

I_Q

I_{QU}

t_{filter}

under current condition detected

V_{ST}

under current condition signalized

t_D

status signal is changed by internal reset

99AT0065   note: parameters are not shown proportionally
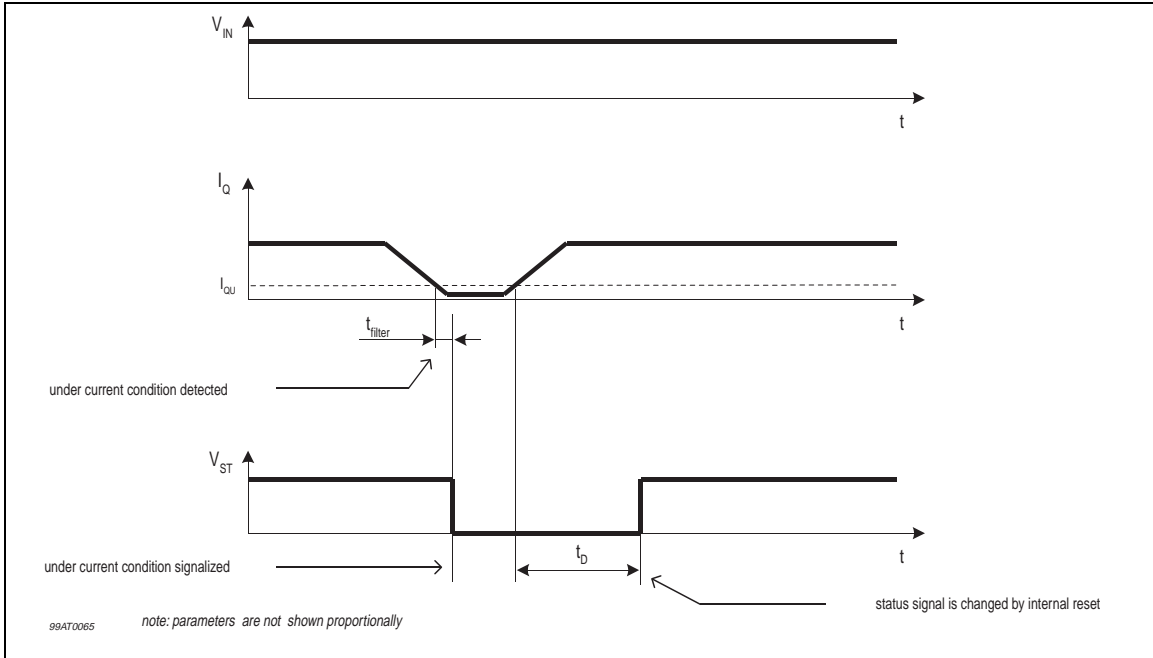
Figure 8. Open Load Condition in Off State

V_{IN}

V_Q

V_{QU}

$t_{detection}$ t_{OLOFF} $t_{detection}$ t_{OLOFF}

openload condition detected
but not signalized due to:
$t_{detection} < t_{OLOFF}$

openload condition detected
and signalized due to:
$t_{detection} > t_{OLOFF}$

V_{ST}

t_D

99AT0066   note: parameters are not shown proportionally
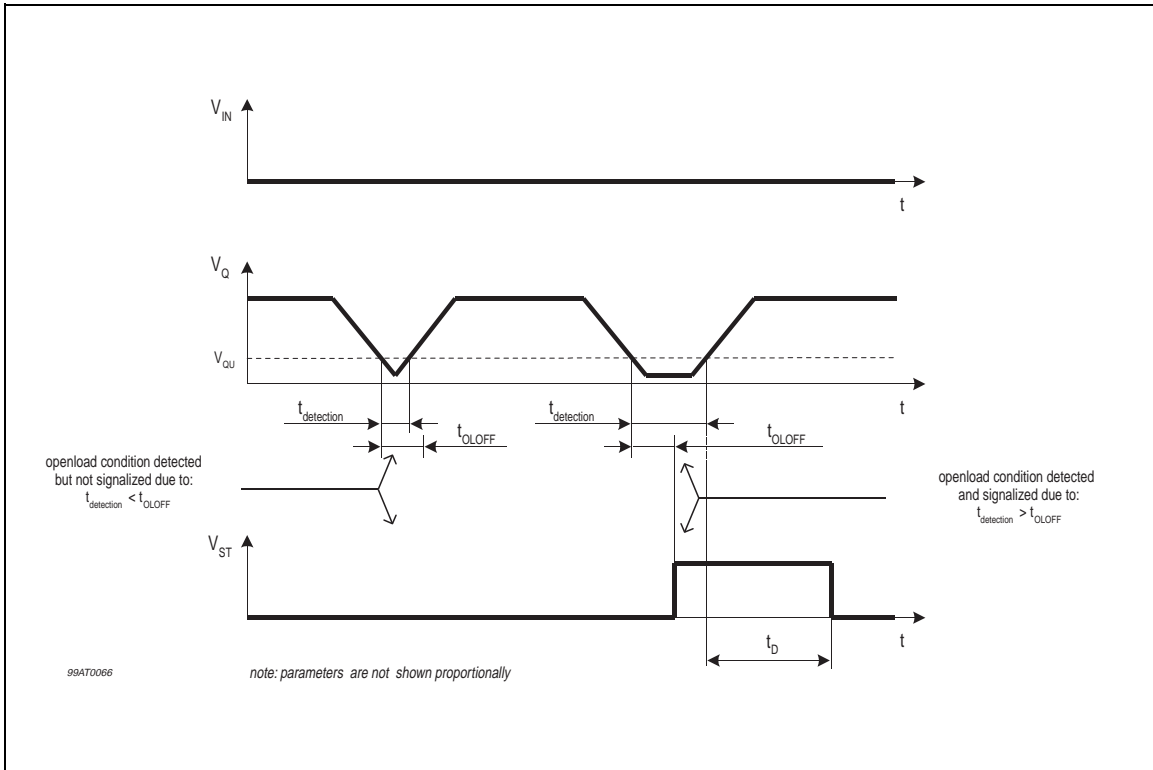
Figure 9. Output Voltage Clamp Detection
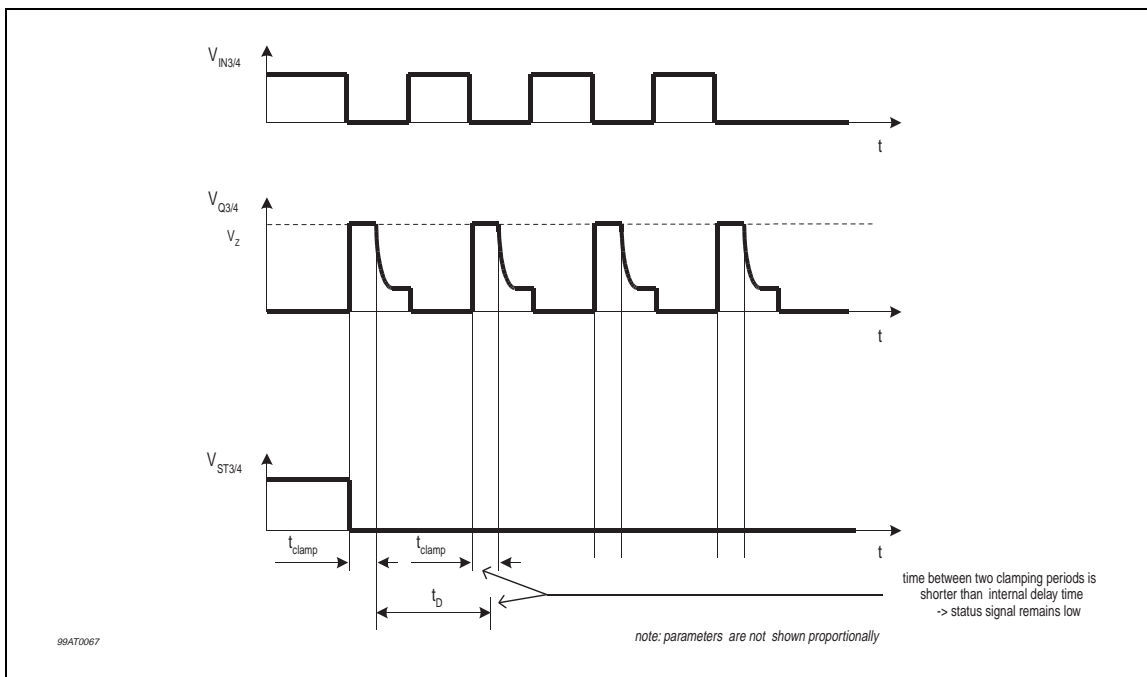
3.0 PAD POSITIONS

Chip Size: 5.17 x 2.76 mm^2

Figure 10.
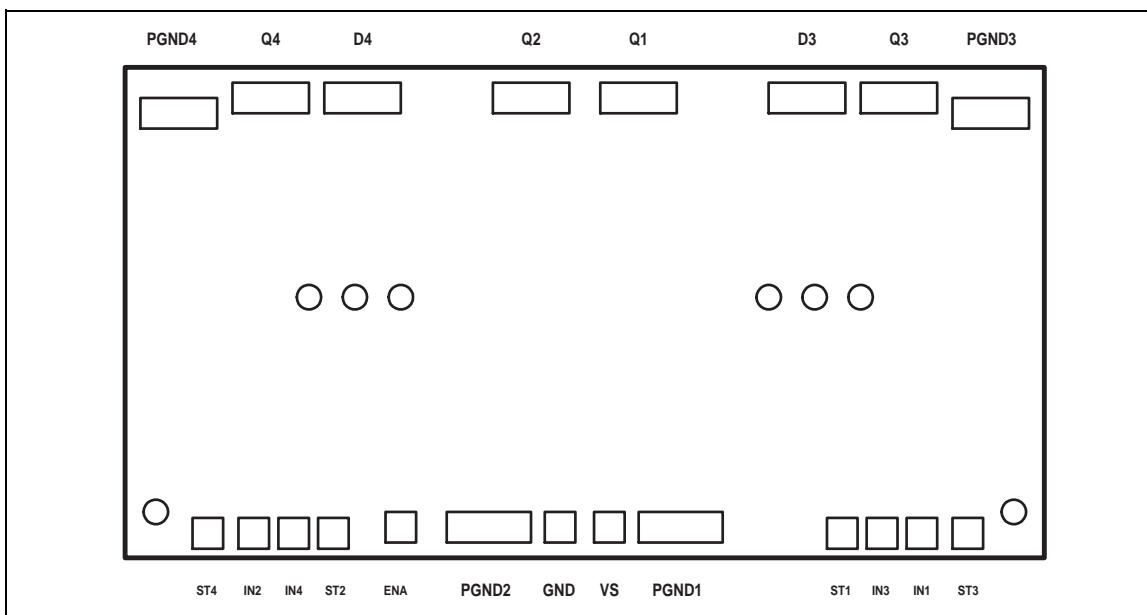
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.60			0.141
a1	0.10		0.30	0.004		0.012
a2			3.30			0.130
a3	0		0.10	0		0.004
b	0.22		0.38	0.008		0.015
c	0.23		0.32	0.009		0.012
D (1)	15.80		16.00	0.622		0.630
D1	9.40		9.80	0.370		0.385
E	13.90		14.50	0.547		0.570
e		0.65			0.0256	
e3		11.05			0.435	
E1 (1)	10.90		11.10	0.429		0.437
E2			2.90			0.114
E3	5.80		6.20	0.228		0.244
E4	2.90		3.20	0.114		0.126
G	0		0.10	0		0.004
H	15.50		15.90	0.610		0.626
h			1.10			0.043
L	0.80		1.10	0.031		0.043
N	10°(max.)					
S	8 °(max.)					

(1): "D" and "E1" do not include mold flash or protrusions
- Mold flash or protrusions shall not exceed 0.15mm (0.006 inch)
- Critical dimensions are "a3", "E" and "G".

OUTLINE AND MECHANICAL DATA

PowerSO36